Ocean Color Experiment Ver. 3 (OCE3)

~ Concept Presentations~

Structural Analysis

August 29, 2008

Outline

Summary

- **The OCE3, as presented in the IDL, was modeled and updated to assess how well it meets structural analysis goals.**
  - OCE3 *partially meets* the analysis goals
    - Fundamental frequency (stowed) > 35 Hz
      - Actual 22 Hz
  - Positive stress margins of safety for a 12g load in each axis
    - Lowest MS=0.24

Scope of Structural Analysis Effort

- **The primary intent of this structural analysis is to verify the feasibility of the IDL mechanical design for OCE3**
  - These designs are considered a "point" designs and have not been thoroughly analyzed or optimized. Results of these analyses should be considered in that light. The structure was analyzed for stiffness and strength only
- **Preliminary loads and stiffness requirements were used**

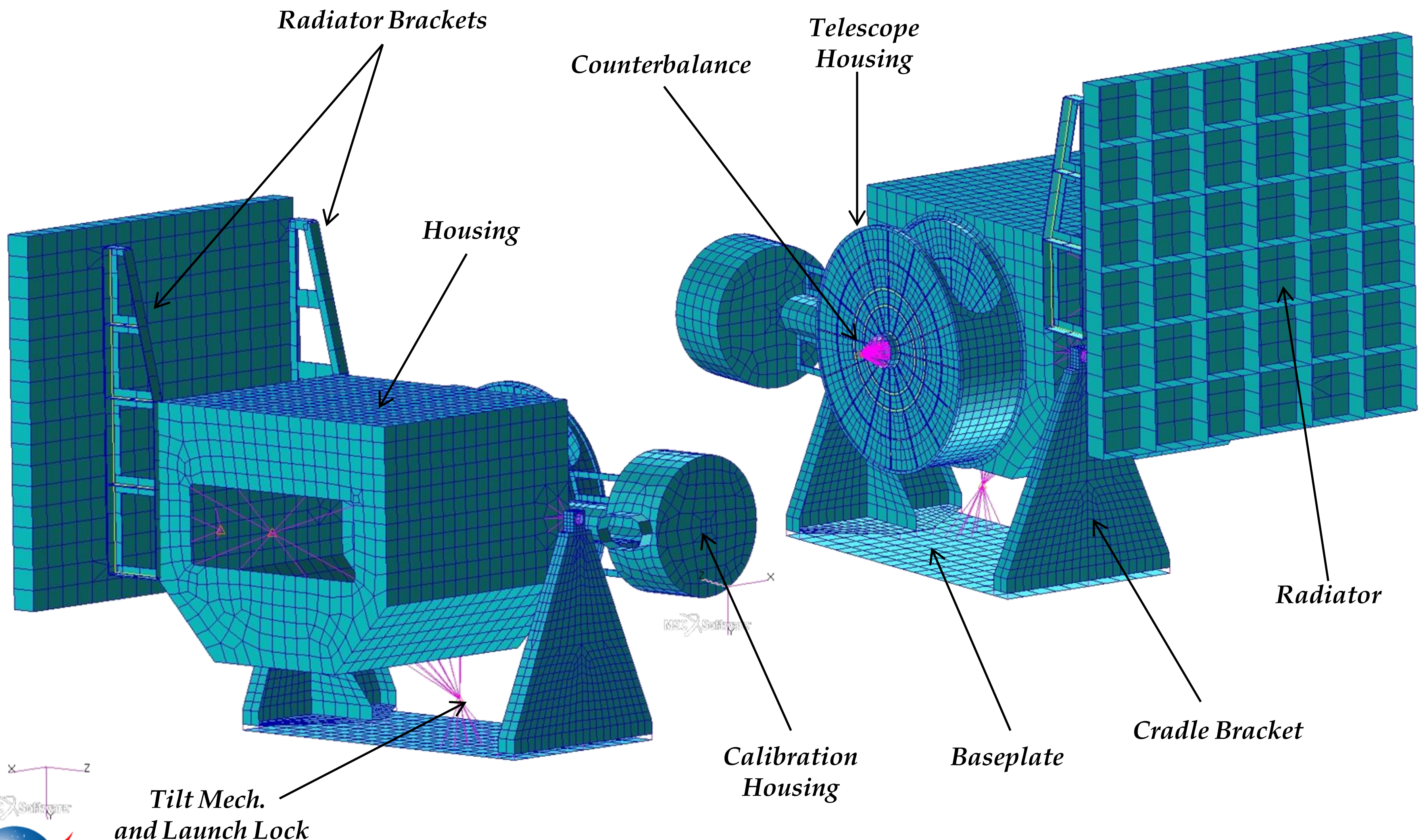
Structural Analysis Goals

- **Structural goals were specified for OCE3**
  - Fundamental Frequency for launch > 35 Hz
    - Based on frequency guidelines associated with component mass of 280 Kg
  - Structural Load Limits
    - 12g in all axes independently
      - Conservative level for a payload 280 Kg using generic mass acceleration curve
- **Factors of Safety**
  - 1.25 on material yield
  - 1.4 on material ultimate
  - Values taken from GEVS

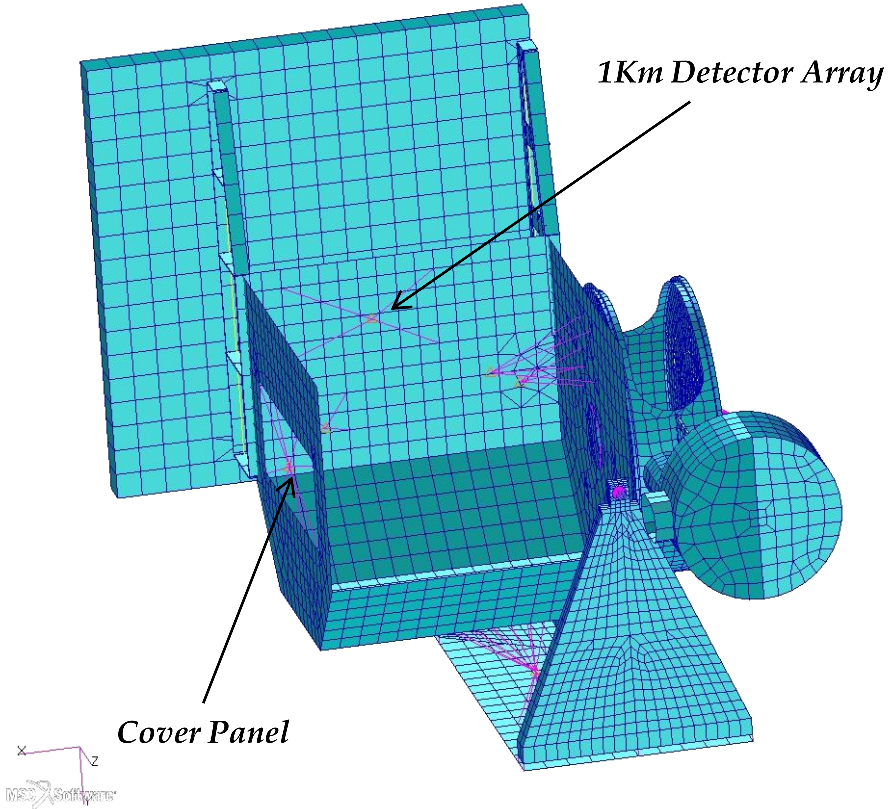
Analysis Assumptions For OCE3

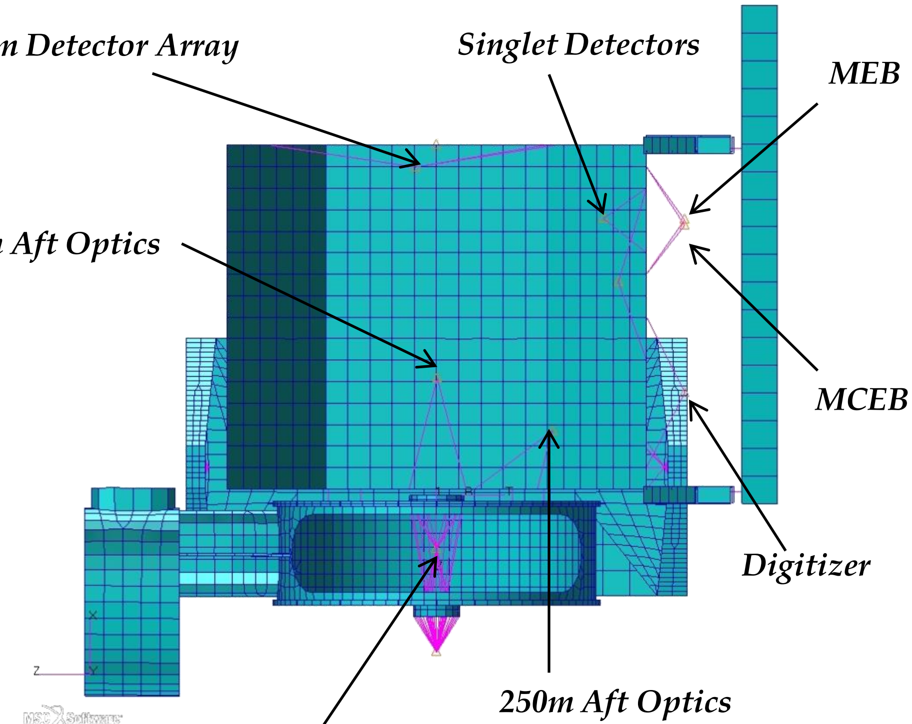
- **Primary and major secondary structural load paths modeled**
  - *Housing, telescope and calibration housing, cradle structure, and radiator*
- **Non-structural mass components modeled as lumped masses at the appropriate location or smeared over structure using values shown in the MEL**
  - *Optics (including telescope), mechanisms, electronics, rear cover of housing*
- **Mount conditions**
  - Held rigidly at multiple locations on base plate
- **Analyzed instrument weight = 283.4 Kg**
  - Structure Weight = 122.7 Kg
  - Lumped Mass Weight = 108.3 Kg
  - Smeared Mass Weight = = 52.5 Kg
- **MEL Mass = 279 Kg**

OCE3 Finite Element Model



OCE3 Finite Element Model (Interior)





MEB
MEB

Structural Analysis Results

Analysis Results Summary
12 G Quasi Static Load Stress Margins

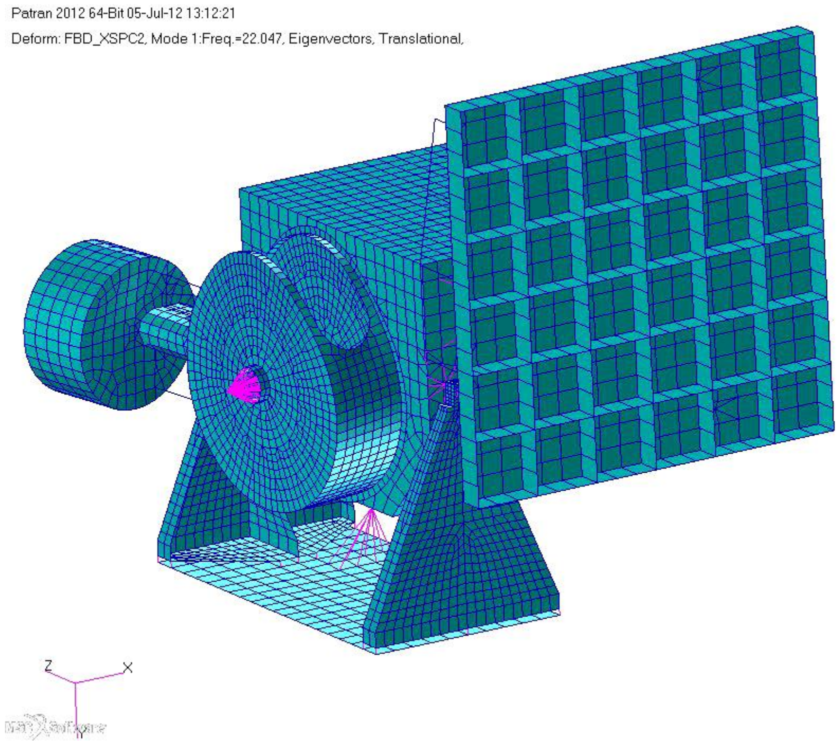
			Stresses (MPa)			Margins of Safety	
Load Case	**Component**	**Material**	**Yield**	**Ult**	**Actual**	**MS_y**	**MS_u**
12g X	Housing	Al 6061-T651 (HC)	2.55E+02	2.96E+02	6.58E+01	2.10	2.22
	Telescope and Calibration Housings	Al 6061-T651	2.55E+02	2.96E+02	1.12E+02	0.82	0.89
	Cradle	Al 6061-T651	2.55E+02	2.96E+02	9.67E+01	1.11	1.19
	Base Plate	Al Honeycomb Panel	2.55E+02	2.96E+02	3.81E+01	4.36	4.56
	Radiator	Al 6061-T651	2.55E+02	2.96E+02	3.06E+01	5.67	5.92
	Radiator Bracket	Al 6061-T651	2.55E+02	2.96E+02	9.93E+01	1.06	1.13
12g Y	Housing	Al 6061-T651 (HC)	2.55E+02	2.96E+02	4.99E+01	3.09	3.24
	Telescope and Calibration Housings	Al 6061-T651	2.55E+02	2.96E+02	5.56E+01	2.67	2.81
	Cradle	Al 6061-T651	2.55E+02	2.96E+02	5.72E+01	2.57	2.70
	Base Plate	Al Honeycomb Panel	2.55E+02	2.96E+02	1.35E+01	14.12	14.69
	Radiator	Al 6061-T651	2.55E+02	2.96E+02	1.72E+01	10.87	11.31
	Radiator Bracket	Al 6061-T651	2.55E+02	2.96E+02	6.56E+01	2.11	2.23
12g Z	Housing	Al 6061-T651 (HC)	2.55E+02	2.96E+02	9.75E+01	1.09	1.17
	Telescope and Calibration Housings	Al 6061-T651	2.55E+02	2.96E+02	8.26E+01	1.47	1.56
	Cradle	Al 6061-T651	2.55E+02	2.96E+02	1.65E+02	0.24	0.28
	Base Plate	Al Honeycomb Panel	2.55E+02	2.96E+02	7.15E+01	1.85	1.96
	Radiator	Al 6061-T651	2.55E+02	2.96E+02	8.99E+00	21.70	22.56
	Radiator Bracket	Al 6061-T651	2.55E+02	2.96E+02	4.19E+01	3.87	4.05

OCE3 Normal Modes Analysis
Mass Participation Percentages

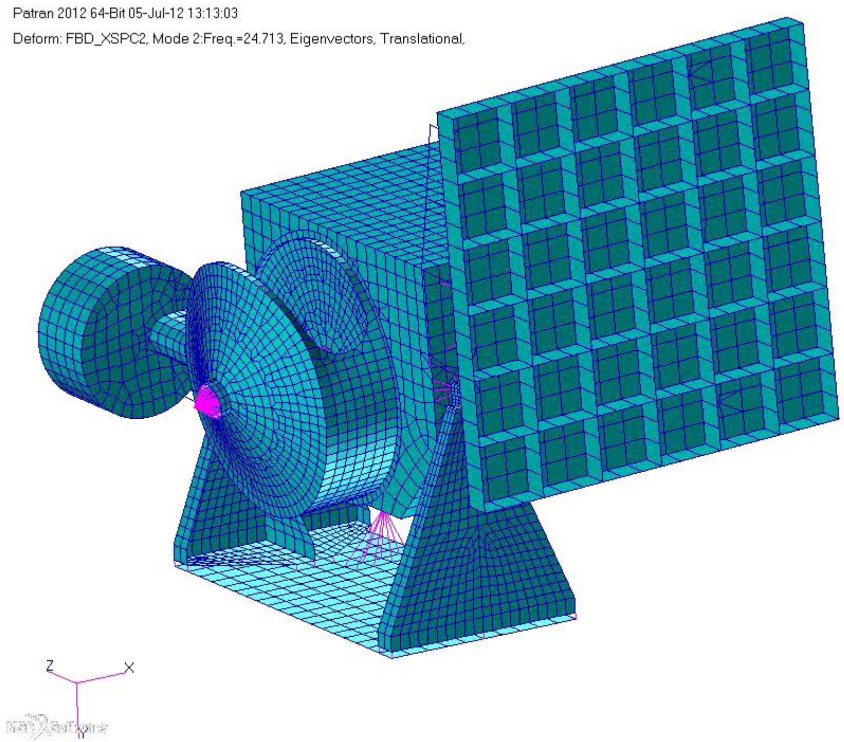
		Modal Mass Participation Percentage					
Mode	Freq (Hz)	TX	TY	TZ	RX	RY	RZ
1	22.15	1.8825%	0.0228%	61.5008%	6.1554%	1.3008%	0.4342%
2	25.01	44.4732%	0.0320%	3.0755%	1.6825%	0.1194%	21.0917%
3	30.46	0.7085%	0.2134%	24.2570%	3.3362%	51.3275%	2.6582%
4	33.70	3.1007%	0.2664%	1.3272%	3.6156%	1.3007%	46.7299%
5	38.54	0.4238%	0.6662%	0.0224%	9.6980%	1.2388%	2.5381%
6	42.56	6.2471%	4.3960%	0.4658%	2.6508%	10.3455%	5.2351%
7	48.81	0.0670%	21.0484%	0.0188%	9.7833%	3.1343%	1.1003%
8	51.37	0.0674%	6.8503%	0.0771%	2.9145%	0.9801%	0.7257%
9	57.70	6.8882%	12.6150%	0.0181%	1.6676%	0.3128%	4.0438%
10	66.45	2.0050%	0.9443%	0.0284%	3.4211%	6.6637%	0.3808%
11	73.65	13.7811%	7.7070%	0.0334%	0.1007%	0.3269%	2.5999%
12	76.91	1.4636%	0.4837%	0.0303%	4.4586%	0.6363%	0.0186%
13	88.31	1.4623%	1.2523%	0.5874%	0.1404%	8.0401%	0.0014%
14	97.75	2.1743%	8.9129%	0.2067%	1.4143%	2.9913%	1.3616%
15	105.88	0.3938%	1.9440%	0.0156%	3.7170%	0.0001%	0.8126%
16	113.39	0.3156%	6.2354%	0.0436%	1.9026%	0.0274%	0.2031%
17	122.56	0.0385%	2.8090%	0.0444%	1.0280%	1.1943%	0.0025%
18	128.73	0.0212%	0.2657%	0.0228%	0.4814%	1.0701%	0.0477%
19	136.41	1.9882%	0.1365%	0.0173%	1.1302%	0.1518%	0.4681%
20	144.83	0.1128%	0.3828%	0.0216%	0.7503%	0.1302%	0.0003%
21	147.55	0.2450%	0.6194%	0.1055%	15.6506%	0.0017%	0.1927%
22	151.24	1.0683%	2.1688%	0.0115%	0.4905%	0.0516%	0.2423%
23	155.91	0.1134%	3.9825%	0.0249%	1.0752%	0.0696%	0.0102%
24	157.72	0.1849%	2.3341%	0.0122%	2.5134%	0.0021%	0.1428%
25	161.64	0.0061%	0.5700%	0.0014%	0.0349%	0.0140%	0.0111%
26	161.76	0.0976%	0.0428%	0.0009%	0.0002%	0.0106%	0.0046%
27	163.42	0.0453%	0.1075%	0.0073%	0.2932%	0.0176%	0.0398%
28	165.91	0.0049%	0.0009%	0.0012%	0.2044%	0.0015%	0.0132%
29	168.94	0.0047%	0.0464%	0.0187%	0.0282%	0.0015%	0.0014%
30	175.46	0.0044%	0.0604%	0.0005%	0.0333%	0.0019%	0.0119%
	Total	**89.39%**	**87.12%**	**92.00%**	**80.37%**	**91.46%**	**91.12%**

OCE3 Mode Shapes
Modes 1 + 2

Mode 1 – 22.05 Hz



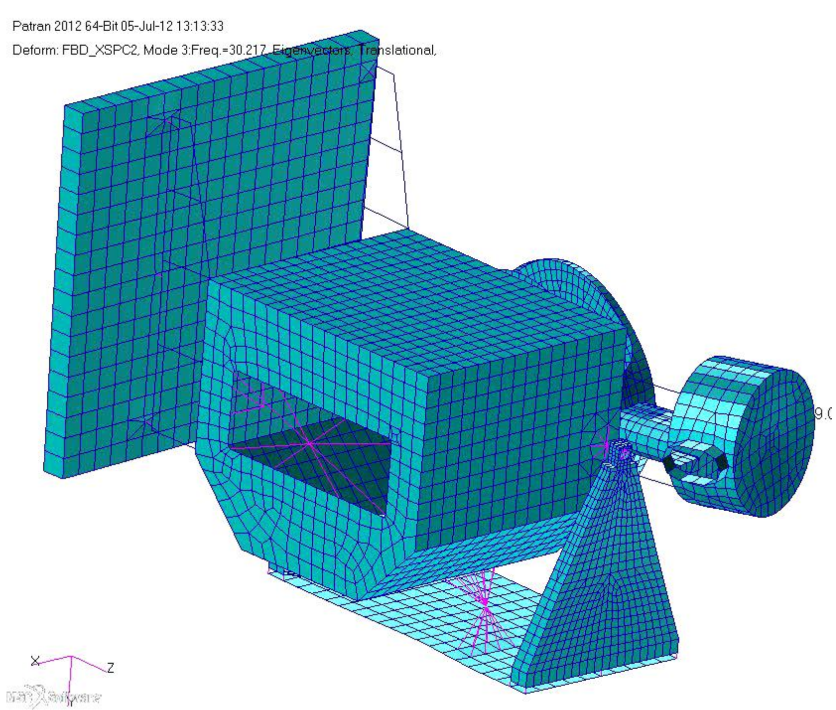
Mode 2 – 24.7 Hz



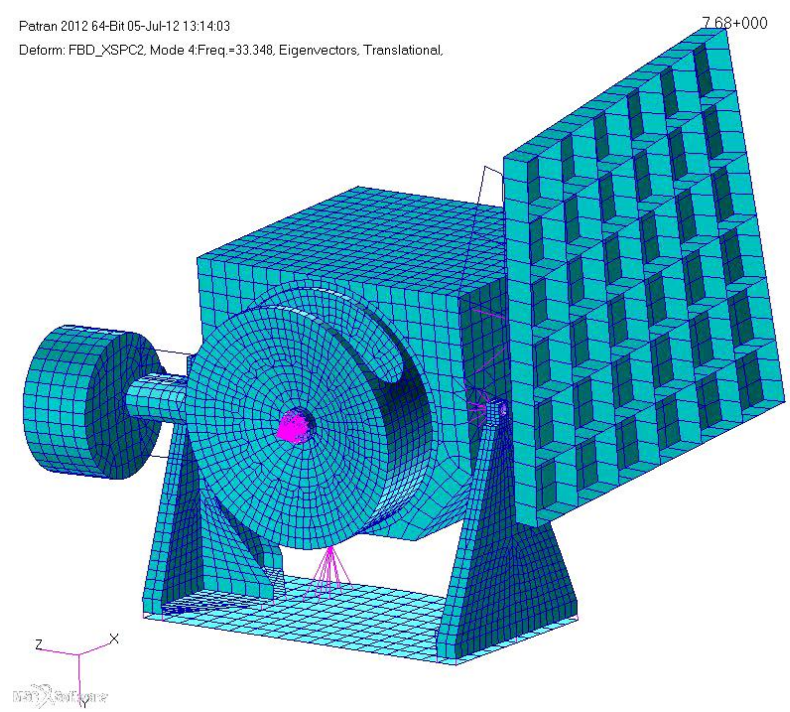
OCE3 Mode Shapes
Modes 3 + 4

Integrated Design Capability / Instrument Design Laboratory

Mode 3 – 30.22 Hz



Mode 4 – 33.35 Hz



Conclusions

- **The proposed OCE3 design partially meets the analysis goals identified**
  - Stiffness goals – FF >35 Hz
    - Actual FF=22 Hz
  - Gross stress goals - Postive MS for 12g load in each axis
    - Minimum MS=0.04
      - Note that the 12 load is partially dependent on a FF that is high enough to avoid coupling with S/C structural modes, so the 12 load may NOT be conservative if the 35 Hz goal is not met
- **Work needs to be done to stiffen the telescope and calibration assemblies**
  - Those structures drive the first modes
  - Additional detail representing the structure and load paths of the rotating telescope and counterbalance may help, as the simplified representation assumes those components to not contribute to the overall stiffness of the system
- **Radiator mounting also needs to be revisited, as that may not quite be stiff enough**
- **Detailed modeling of the tilt mechanism and associated launch lock should also be a priority, as they are currently simplified as rigid**
  - It is likely that there could be significant stress due to launch loads in that component
- **Overall, this design appears to be "stiffness driven" rather than "stress driven"**
  - i.e. – Components seem to be sized fairly well for static loads, but achieving the needed launch stiffness of the structure may be the bigger challenge.